STScI | SPACE TELESCOPE SCIENCE INSTITUTE

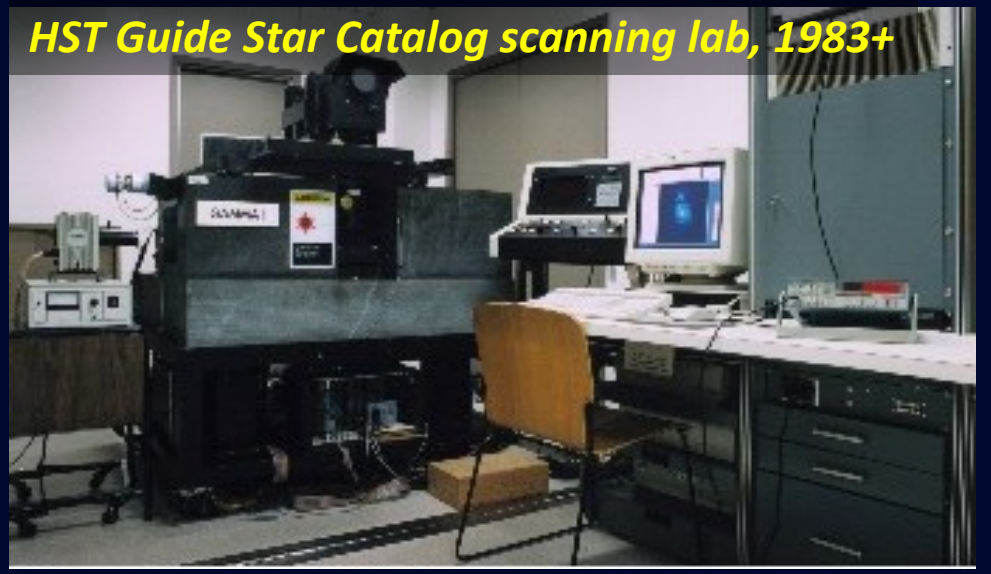
EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

Advancing Technologies for future Segmented Telescopes

Russell B. Makidon Optics Laboratory

Rémi Soummer

STScI's Russell B. Makidon Optics Laboratory



Created in 2013, the Russell B. Makidon Optics Laboratory is dedicated to advancing technologies for future generations of space telescopes.

Our current research focuses on enabling direct images of exoplanets using large segmented telescopes in space using coronagraphy and wavefront control, and advancing multi-object spectroscopy using digital micromirror devices.

Active projects:

- **HiCAT (Demonstration of coronagraphy for LUVOIR**
- **JOST (JWST optical simulation testbed**
- **STUF (STScI UV Facility)**
- **ULTRA (LUVOIR optical stability, Ball)**
- **SCDA (Coronagraph optimizations, ExEP)**

Who we are

Current active team ~12-15 people including four graduate students and one postdoc

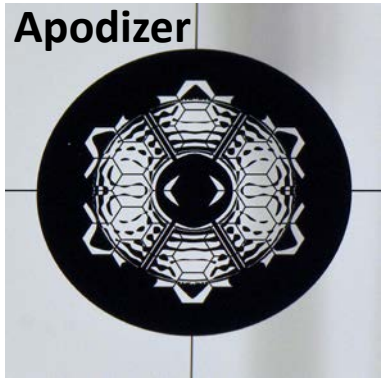
Summer 2019

Transition to remote work since the beginning of the pandemic

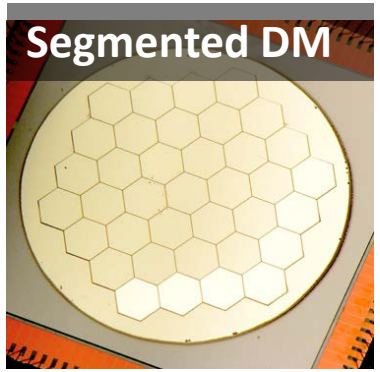
Spring 2020

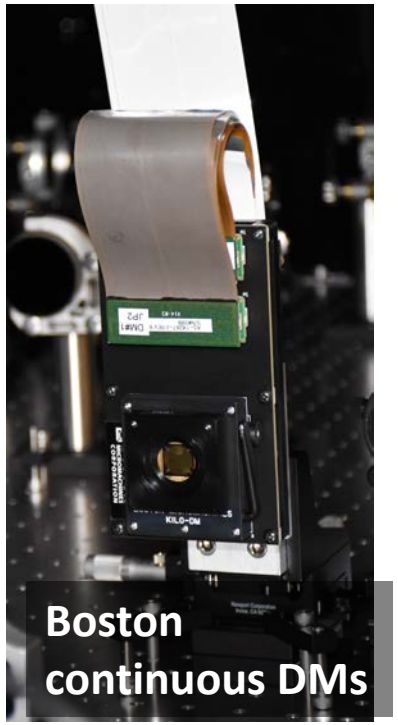
HiCAT – Coronagraphy on segmented apertures

Coronagraph

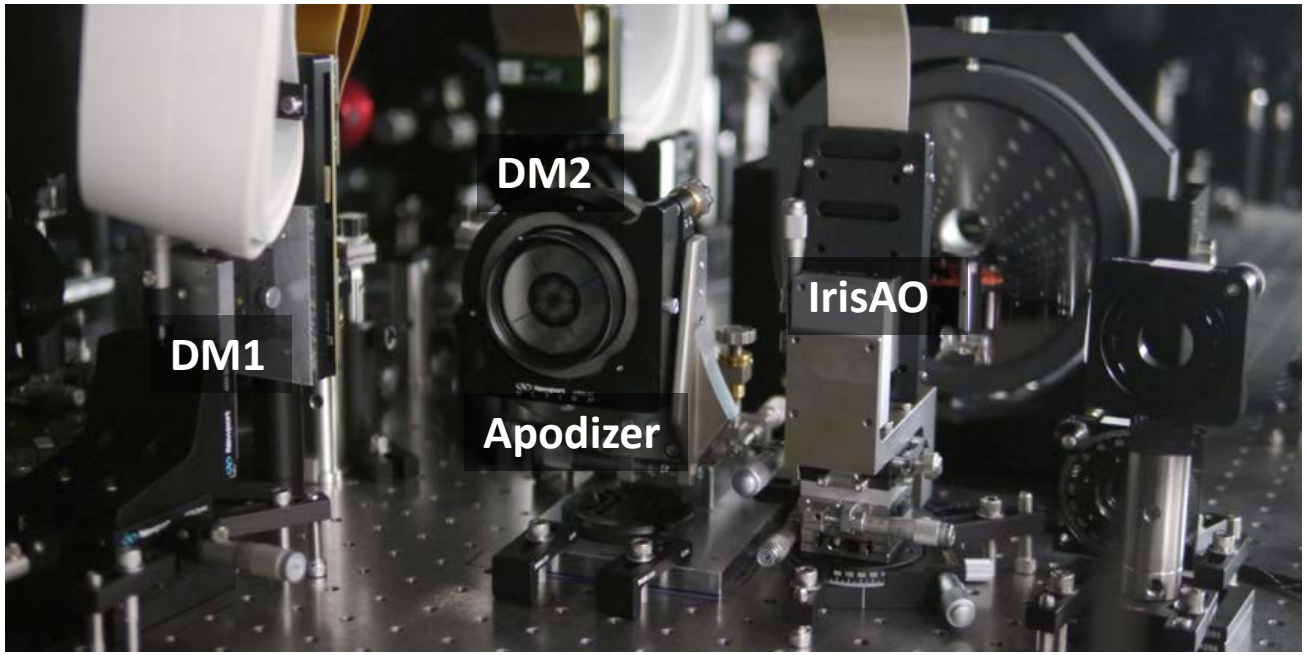


WF sensing & control





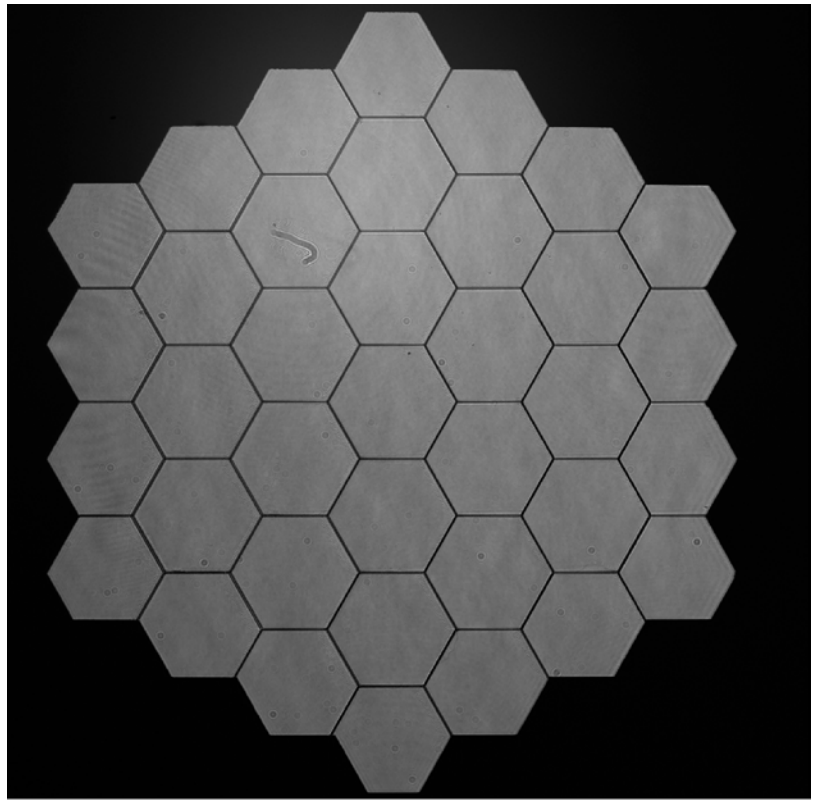
- **Goal: demonstration of coronagraphy for a LUVOIR-like segmented aperture**
- **Contrast: 10^{-7} to 10^{-8} in air**
- **SAT-TDEM funding**



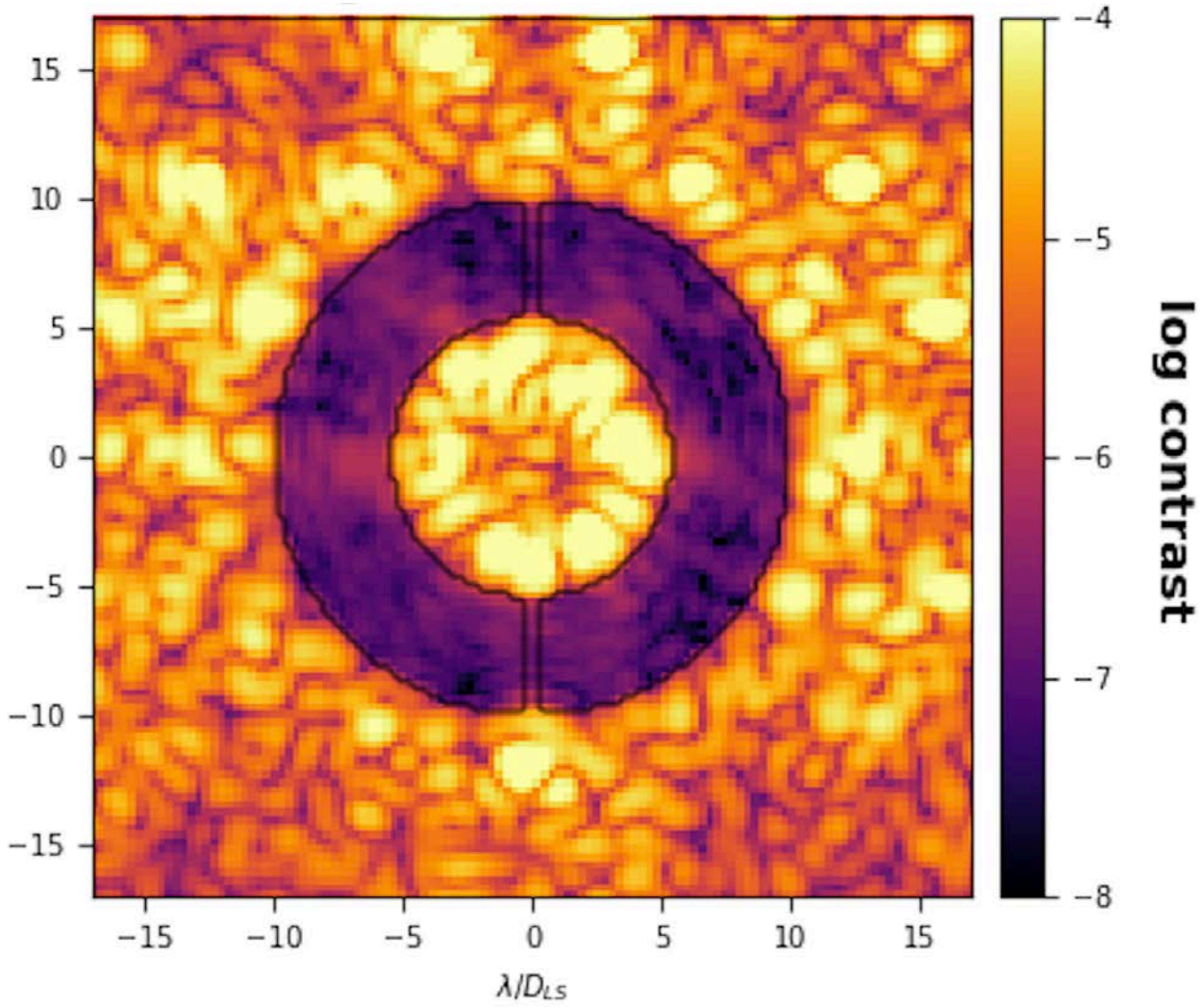
First result with fully segmented aperture

Transition to fully segmented configuration December 2020

Preliminary contrast with partial calibration 2e-7



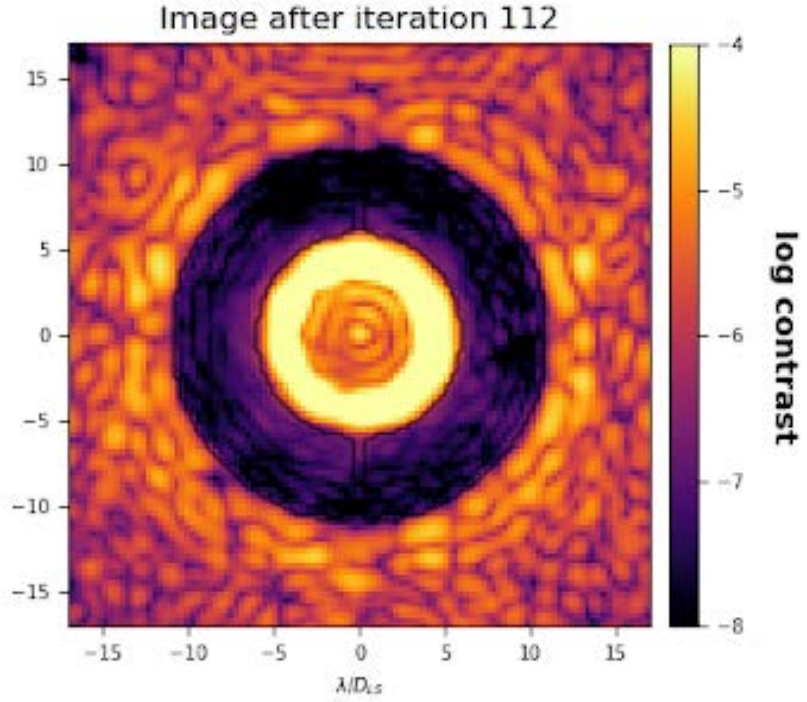
Segmented pupil image

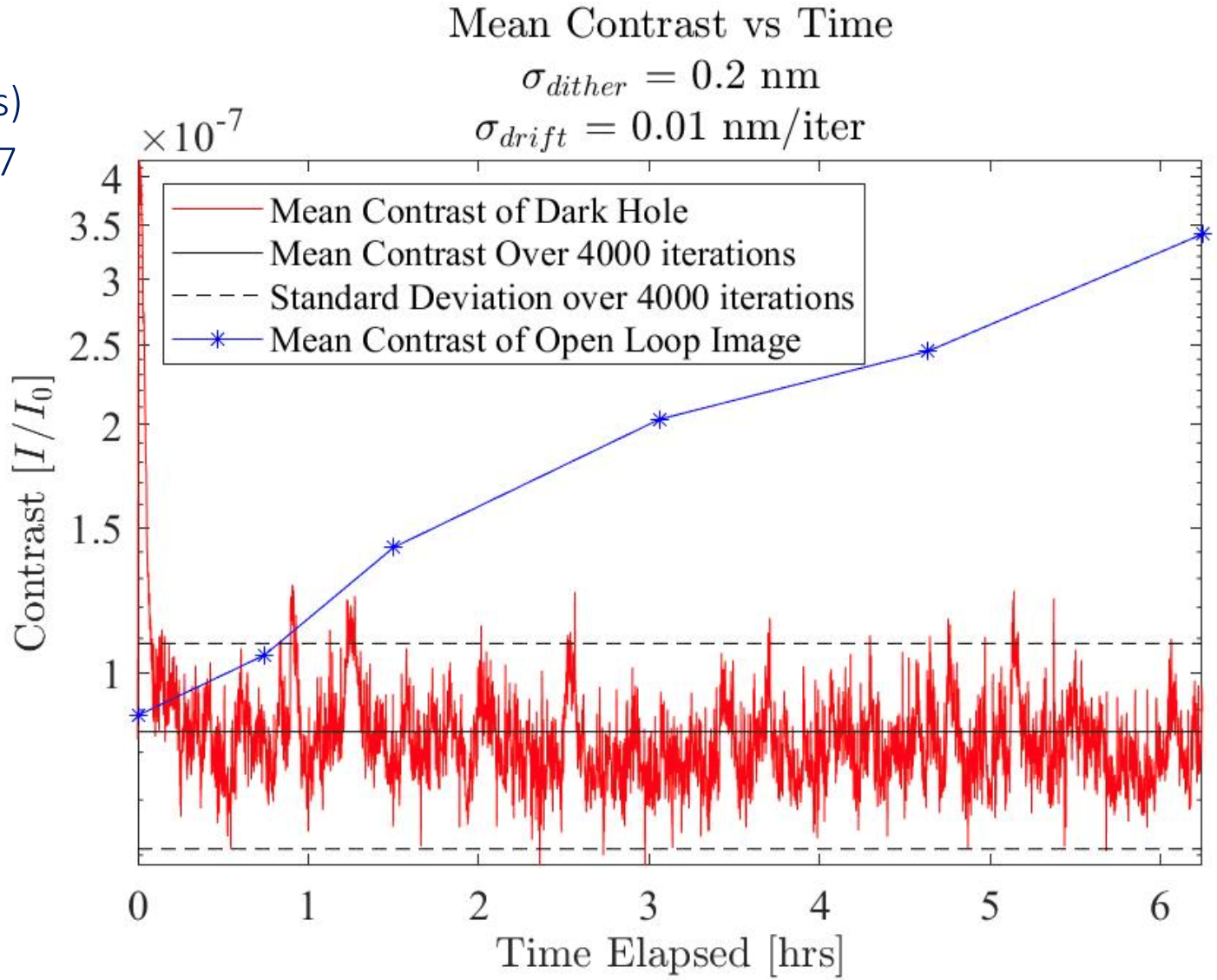


360 deg dark hole

Wavefront Maintenance under in the presence of artificial drifts

- Unobstructed monolithic aperture
- 0.01 nm random drift per iteration (4000 iterations)
- 8e-8 stable contrast over 6 hours compared to 4e-7 open loop measured contrast
- Susan Redmond (PhD student Princeton), SPIE astronomical instrumentation 2020

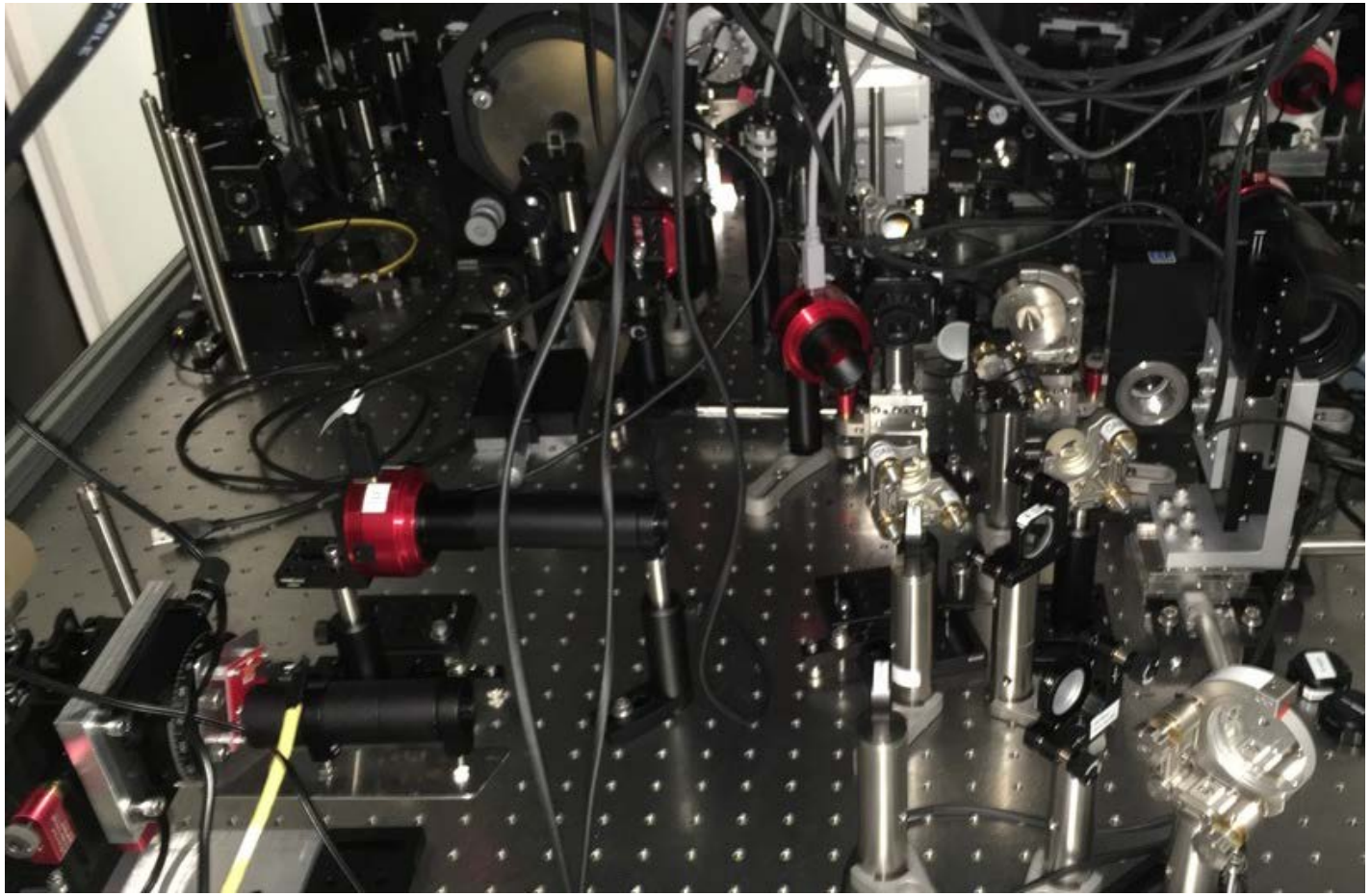




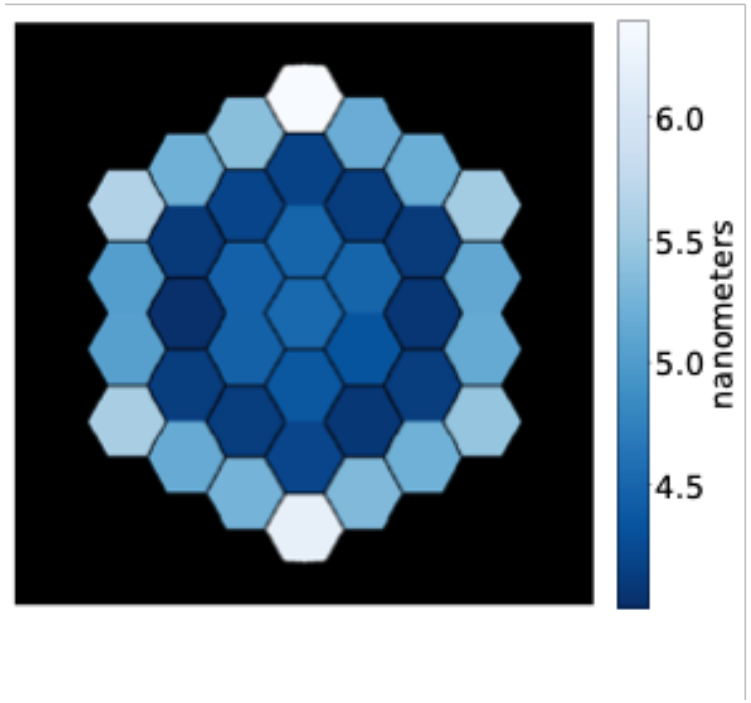
Low-order wavefront sensor

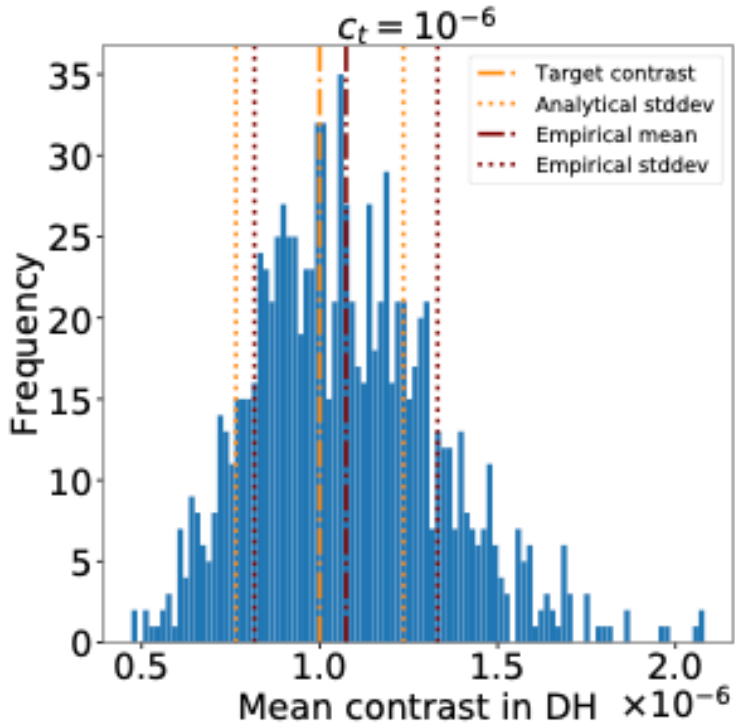
- LOWFS Installed and aligned this summer together with tip-tilt sensor and target acquisition camera
- Similar kind of Zernike sensor as used on NGRST CGI

- Raphaël Pourcelot (PhD student Univ. Nice) SPIE astronomical instrumentation 2020



Modeling of segment-level tolerances to be validated on hardware

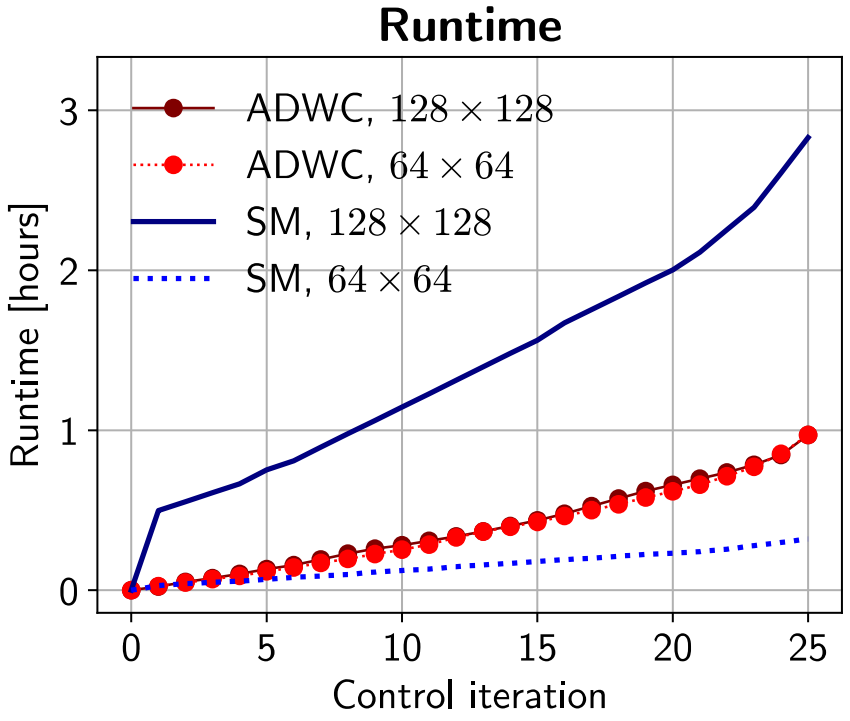


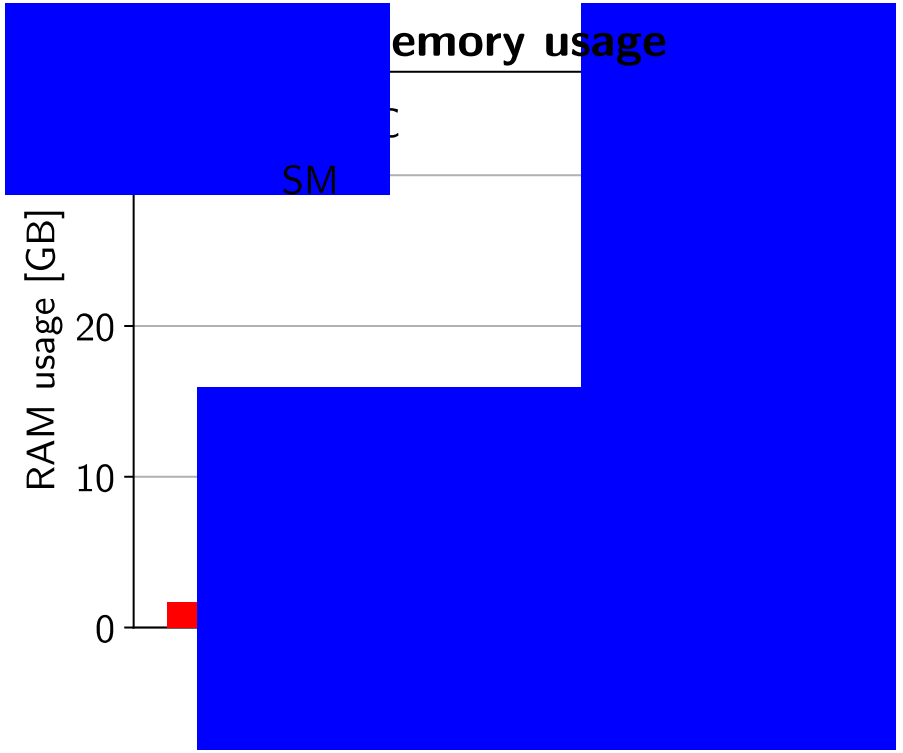


- Segment piston tolerances from analytical model to reach a given contrast (here 1e-6) starting from 5e-8 baseline contrast
- Hardware validation upcoming soon

Iva Laginja, PhD student STScI/ONERA/LAM, SPIE astronomical instrumentation 2020

Jacobian-free coronagraphic wavefront control



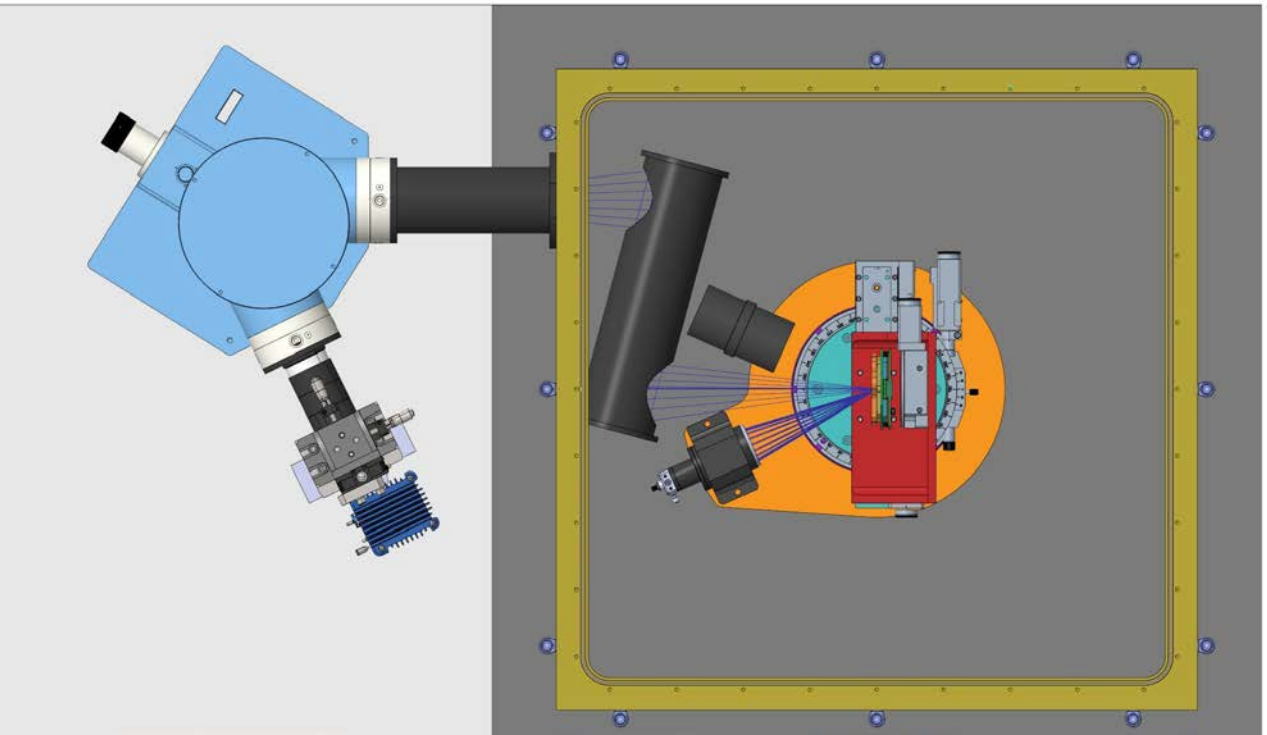


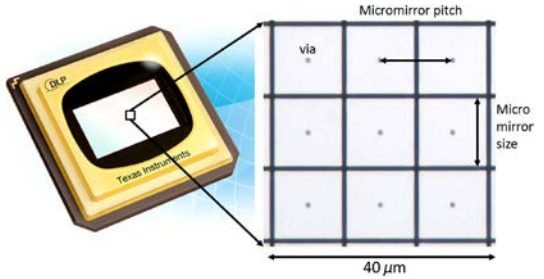
- Non-linear optimization based on analytic gradients to find deformable mirror solutions without a more traditional finite-difference Jacobian matrix
- Gain in execution time and memory usage. Implementation on HiCAT in 2021
- **Scott Will, PhD student Rochester/STScI**

STScI UV Facility (STUF)

- Study of digital micromirror devices (DMDs) as slit-selection mechanism for multi-object spectroscopy
- Goal: characterize the optical properties of DMDs in the ultraviolet, with the goal of advancing this technology to the point where it will be usable in space.

PI: Mario Gennaro



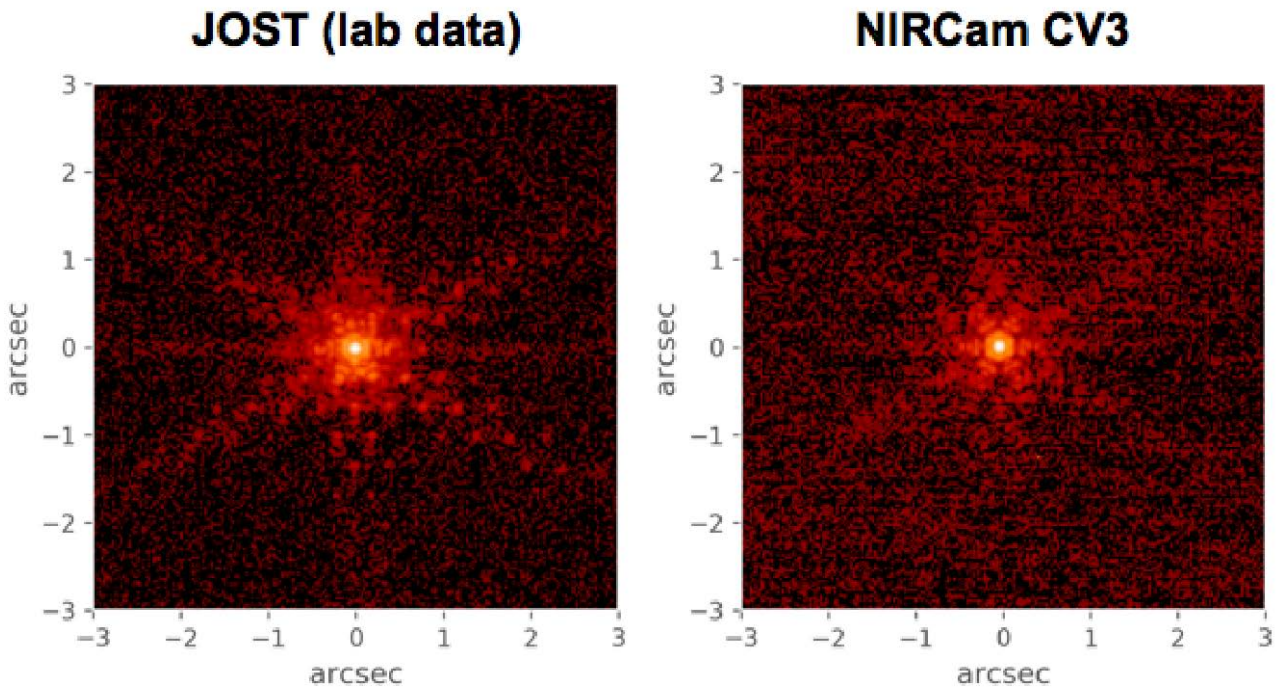


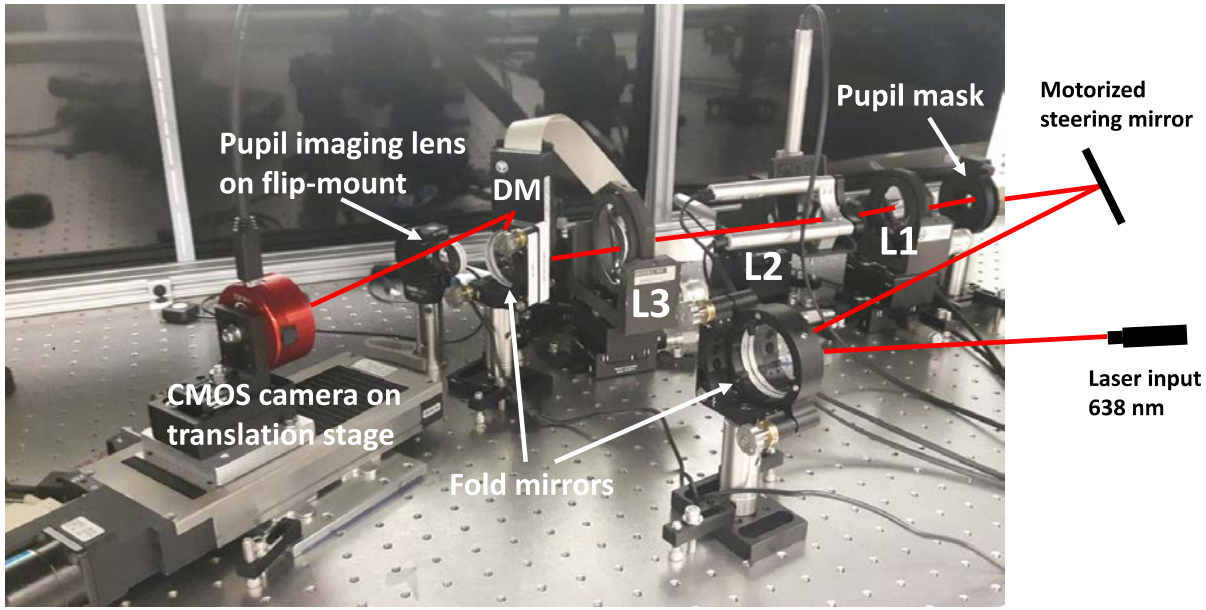
Software completed to control the DMD directly

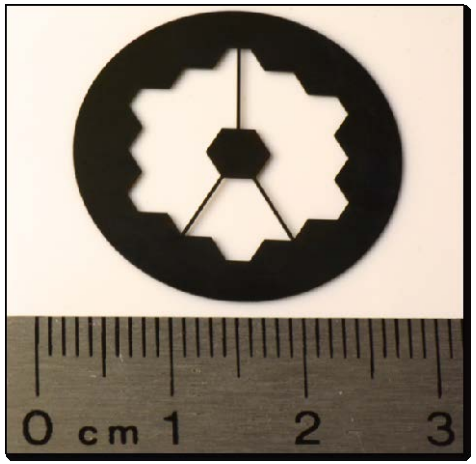
Preliminary design of the reflectometer, with DMD illuminated in the way it would be on an actual instrument (i.e. at the focus of a f/4 beam).

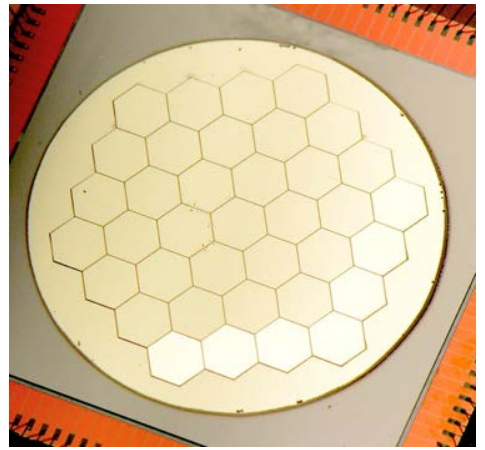
JWST Optical Simulation Testbed

- Simplified, lens design in the visible with similar image quality as JWST over wide field .
- Wavefront sensing studies, new algorithm testing, and staff training









Summary

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- Our current research focuses on enabling direct images of exoplanets using large segmented telescopes in space using coronagraphy and wavefront control, and advancing multi-object spectroscopy using digital micromirror devices.
- Ongoing progress despite this year's challenging remote operations during the pandemic
- Advanced testbed operations and open platform for community collaborations, with several external collaborators and remote PhD students